

Determination of the polarization in the $\vec{p}p \rightarrow pp$ reaction with WASA-at-COSY detector

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The dynamics of η -meson production and the interaction of η -mesons with nucleons can be studied using the $\vec{p}p \rightarrow pp\eta$ reaction via measurements of the analyzing power A_y . To this end, we have performed a measurement of the $\vec{p}p \rightarrow pp\eta$ reaction using the WASA-at-COSY detector, which provides large acceptance and is φ -symmetric. The experiment was carried out for beam momenta of 2026 MeV/c and 2188 MeV/c. In this article we present a method and results for the determination of the degree of the beam polarization.

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1. Introduction

Despite a number of experiments [1–13] and theoretical approaches [14–22] still an open question remains about the mechanism of the η -meson production in nucleon-nucleon collisions. Previous studies concluded that the $N^*(1535)$ resonance and that the proton- η interaction is much larger than in the case of proton- π^0 , and proton- η' [23–27]. For an unambiguous understanding of the η production process, relative magnitudes from the partial wave contributions must be well established. The incompatibility between experiment and theory may be resolved by taking into account higher partial waves and additional baryon resonances [28]. This kind of studies can

be performed by measuring analyzing power A_y of the η -meson. Up to now, measurements of A_y in the $\vec{p}p \rightarrow pp\eta$ reaction were conducted by the COSY-11 and DISTO collaborations [29–32]. However, these previous experiments suffered from low statistics and limited geometrical acceptance [33, 34]. In order to determine A_y more accurately, the axially symmetric WASA detector [38] and the vertically polarized proton beam of COSY have been used to collect a high statistics data sample. An experiment was conducted for beam momenta 2026 MeV/c and 2188 MeV/c which correspond to excess energies of 15 MeV and 72 MeV, respectively [35, 39]. The trigger was set to select events corresponding to the $\vec{p}p \rightarrow pp\eta$ and $\vec{p}p \rightarrow pp$ reactions. Proton-proton elastic scattering provides information for the determination of the polarization and the luminosity. Additionally, to control the effects caused by potential asymmetries in the detector setup the spin orientation was flipped from cycle to cycle.

2. Extraction of the $pp \rightarrow pp$ reaction

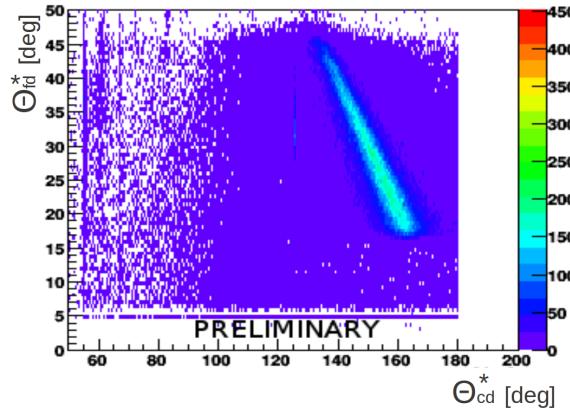
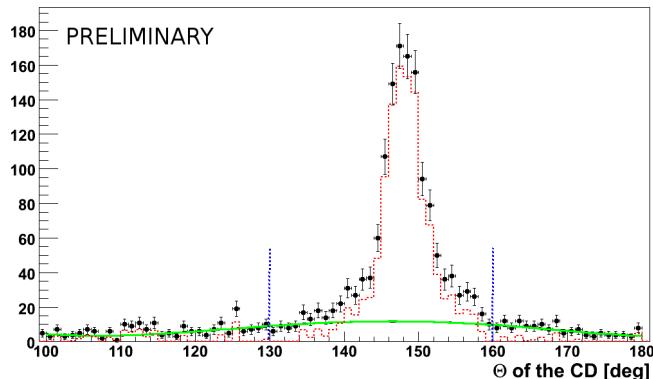
The first step in the study of the asymmetry A_y is the analysis of the reaction $\vec{p}p \rightarrow pp$. Based on the elastic scattering reaction we have calculated the polarization degree for the whole data sample. In the $\vec{p}p \rightarrow pp$ reaction one of the protons is registered in the Forward Detector, with geometrical acceptance of polar angle θ_{FD} from 3° to 18° and the second is registered in the Central Detector. By utilizing ΔE -E method in the Forward Range Hodoscope and the angular correlation of the outgoing protons we have selected events corresponding to the proton-proton elastic scattering. For further calculations we have chosen only two θ_{FD}^* ranges in the centre of mass $[30^\circ - 34^\circ]$ and $[34^\circ - 38^\circ]$, for which A_y is available from EDDA database [41] and for which the number of event statistic was sufficient. In order to estimate the background, for each bin in θ_{FD}^* , the θ_{CD}^* distribution was fitted separately with a fifth-order polynomial, excluding in the fit the range from 130° to 160° , as shown in Fig. 1.

Subsequently in order to estimate a background each separate θ_{CD}^* distribution was fitted with the fifth polynomial excluding in the fit the range from 130° to 160° . Example of such distribution can be seen in Fig. 2

3. Polarization determination

The polarization was determined from elastic scattering events by the following equation:

$$\frac{N^{exp}(\theta, \varphi) - N^{exp}(\theta, \varphi + 180)}{N^{exp}(\theta, \varphi) + N^{exp}(\theta, \varphi + 180)} = P \cdot \cos \varphi \cdot A_y(\theta) \quad (1)$$

Fig. 1. Example of the θ_{FD}^* vs θ_{CD}^* distribution.Fig. 2. The distribution of θ_{FD}^* for $\theta^* \in [30^\circ, 34^\circ]$, $\varphi \in [20^\circ, 30^\circ]$ and spin mode. Points denote data. The green line corresponds to the fitted background, and the dotted red histogram shows the data after subtraction of the background.

where $N^{exp}(\theta, \varphi)$ and $N^{exp}(\theta, \varphi + 180)$ correspond to a given angular bin after correction for the acceptance, and P denotes the polarization. $A_y(\theta)$ was calculated based on the results of the EDDA experiment [41]. The procedure is described in detail elsewhere [36].

The polarization determined from all experimental data is shown in Fig. 4. The upper panel shows the results for measurements with a polarized beam obtained for both studied beam momenta. The lower panel presents the polarization of the control sample, which has been measured

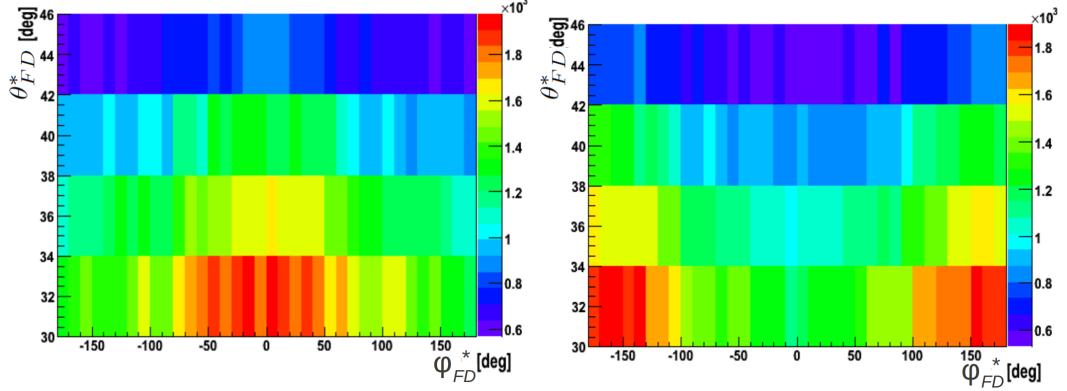


Fig. 3. Example of the angular distribution for the elastic scattered events. Left: spin up mode. Right: spin down mode.

with an unpolarized beam. In the case of the control sample, the measured polarization is consistent with zero, within the statistical uncertainty. Fig. 4 shows the results before and after the correction for shifts of the center the interaction region between the beam and the target [36, 37].

The average polarization of all acquired data was calculated analyzing all events together. The results are shown in Tab.1.

p_b [GeV/c]	spin mode	polarization
2026	down	0.793 ± 0.010
	up	-0.577 ± 0.007
2188	down	0.537 ± 0.009
	up	-0.635 ± 0.011
2026	unpolarized	-0.012 ± 0.005

Table 1. Preliminary polarization achieved in the WASA-at-COSY experiment conducted in the year 2010.

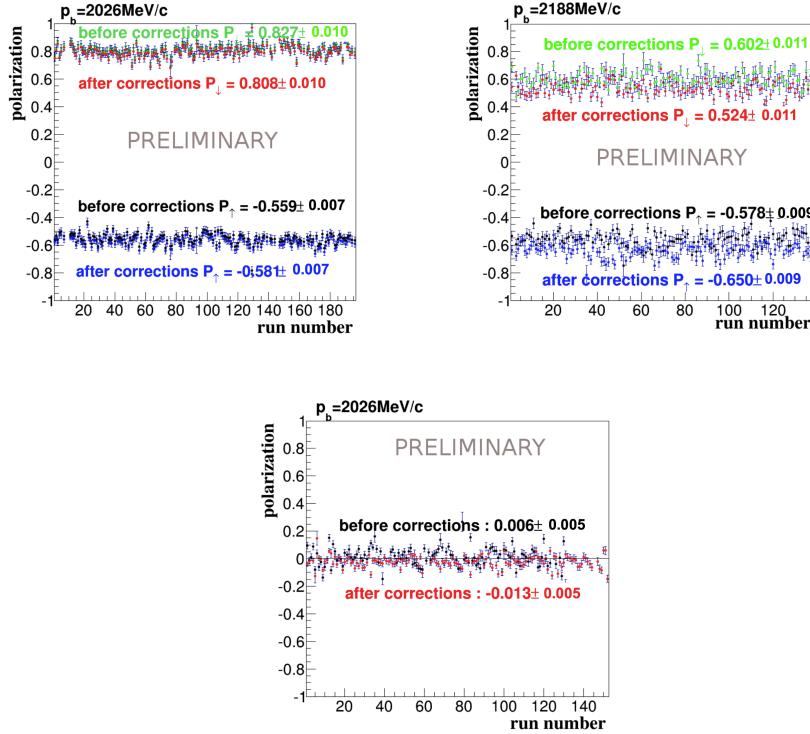


Fig. 4. Distributions of polarization as a function of run number for polarized (upper panel) and unpolarized (lower panel) data. Results for both polarization modes are shown.

4. Summary

The polarization of elastic scattering events in the reaction $\vec{p}p \rightarrow pp$ has been presented. The polarization differs between the spin modes. However, it is stable between runs for the whole period of data taking. Additionally, the value of the polarization for an unpolarized beam has been measured to be consistent with zero, as expected. A high degree of polarization for both beam momenta gives a very good perspective for the determination of the analyzing power for the $\vec{p}p \rightarrow pp\eta$ reaction.

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